MOUNT BAKER-GLACIER PEAK COORDINATION PLAN:

Coordinating efforts between governmental agencies in the event of volcanic unrest at Mount Baker or Glacier Peak, Washington

Austin Post, USGS

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Prepared by the

Mount Baker/Glacier Peak Facilitating Committee

FOREWORD

The Washington State Military Department sincerely appreciates the cooperation and support from the agencies, local jurisdictions and the Province of British Columbia, which have contributed to the development and ultimate publication of the *Mount Baker/Glacier Peak Coordination Plan.*

The Plan provides vital Mt. Baker and Glacier Peak volcanic event response and recovery information that will greatly enhance the hazard planning efforts of three Western Washington counties, the Province of British Columbia and multiple state and federal agencies. The Plan supports and complements local response plans, the *Federal Response Plan and the State Comprehensive Emergency Management Plan.*

The *Mount Baker/Glacier Peak Coordination Plan* is an important element in a coordinated effort to enhance our region's preparedness for emergencies or disasters. This plan embraces the philosophy and vision of a *Disaster Resistant Washington* and will empower local communities to minimize the impacts of emergencies and disasters on people, property, the economy, and the environment of the Pacific Northwest.

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Change #	Date Entered	Contents of Change	Initials

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Mount Baker/Glacier Peak
Suggested Revisions/Improvement

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INTRODUCTION AND PURPOSE

The mountains of the Pacific Northwest were the source of legends by native peoples and continue to awe and inspire people today. They have been the objects of livelihoods, the goals of mountaineers, homes for many, and vacation spots for many more. Not everyone who sees them however, is aware that some of the most prominent peaks are also volcanoes. Best known among them is Mount St. Helens, whose eruption in 1980 forever changed the local population's perspective as to what living near an active volcano may mean. Northwest Washington contains two prominent volcanoes: Mount Baker and Glacier peak. Both have erupted within the last three centuries, and Glacier Peak has produced one of the largest explosive eruptions of the Cascade volcanoes in the past fifteen thousand years.

Populations are sparse around Mount Baker and especially so around Glacier Peak, thus these volcanoes do not pose the same level of risk as nearby Mount Rainier, nor do they erupt as frequently as Mount St. Helens. Nevertheless, an eruption or major landslide-produced ***lahar***[1] could cause significant disruption and possibly loss of life in affected areas. As generally noted by geologists, "it's not a question of 'if', but 'when'" either volcano will erupt. When the next eruption or landslide-produced lahar occurs, its effects will be more easily dealt with if a plan is in place so that responsible agencies know what to expect and how to respond.

For this reason, the Mount Baker/Glacier Peak Coordination Plan was drawn up by emergency managers from Snohomish, Skagit, and Whatcom Counties, the State of Washington, and the Province of British Columbia, as well as personnel from the U. S. Forest Service and the U.S. Geological Survey. The purpose of this plan is to coordinate the actions that various agencies must take to minimize loss of life and damage to property before, during, and after a hazardous geologic event at either volcano. The plan strives to assure timely and accurate dissemination of warnings and public information. The plan also includes the necessary legal authorities as well as statements of responsibilities of County, State, and Federal agencies in the United States and Provincial and Federal agencies in Canada.

GEOLOGIC BACKGROUND

The volcanoes of Mount Baker and Glacier Peak differ in their topographic form, in the type of ***magma*** they produce, in the nature and style of their eruptions, and in the kinds of hazards they present. The main characteristics of these volcanoes are as follows:

Mount Baker

Mount Baker is an ice-clad volcano prominently visible from the communities of Bellingham, Washington, and Vancouver, British Columbia. At 10,775 feet (3284 m) in elevation, it is the third highest volcano in Washington. Since the disappearance of continental ice sheets from this area about 14,000 years ago, volcanic activity has been dominated by eruptions producing lava flows and minor ash falls, and by small to moderate ***debris avalanches*** and lahars. During this period:

- Small volumes of ash were erupted at least 4 times; the largest of these (about 6,000 years ago) produced an ash layer as thick as 20 inches (50 cm) at a distance of seven miles (11 km) northeast of the volcano. Some of these events involved new magma; others (most recently around 1843) resulted from violent steam explosions.

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[1] Terms in ***bold italics*** are defined in the glossary in Appendix B.

- Lava flows were erupted at least twice and moved down Boulder Creek valley and Sulphur Creek valley, in the latter to a distance of 7 miles (12 km) from the vent.
- During one eruptive episode, numerous hot ***pyroclastic flows*** (rapidly moving mixtures of rock, ash, and gas) moved down the Boulder Creek valley into the Baker River valley.
- About 6,000 years ago, the south flank of Mount Baker collapsed, producing a voluminous lahar whose deposits extend down the Nooksack River at least as far as Deming. Farther downstream the deposits are buried by younger river sediments, but the lahar probably reached Puget Sound. The lahar may have also overtopped the divide near Everson and flowed down the Sumas River into the Fraser River valley.
- Debris avalanches (***rock avalanches***) and small to moderate-sized lahars have occurred repeatedly. Lahars that occurred during the hydrothermal explosions of 1843 record the collapse of the east rim of Sherman Crater and affected all the major drainages on the east flank, from Sulphur Creek to Rainbow Creek. These lahars apparently caused a rise of about 8 feet (2.5 m) in the level of the natural Baker Lake (a small body of water about a mile upstream of the mouth of Swift Creek). Since the 1840s there have been at least ten small debris avalanches, lahars, or ***glacial outburst floods***. Most reached only one to two miles (2-3 km) from their source areas; a few traveled about six miles (10 km).
- In 1975, increased ***fumarolic*** activity in the Sherman Crater area caused concern that a hazardous volcanic event might be imminent. For a time, local access was restricted, and the level of Baker Lake was lowered. Enhanced monitoring eventually showed that surface heat flow had increased, but that magma had not moved to shallow levels and that an eruption was not imminent.

Potential future hazards

- The most common events at Mount Baker are debris avalanches and lahars. Small- to moderate-sized debris avalanches and lahars occur more frequently than large ones and may occur during volcanic quiescence (Fig. 1). Small debris avalanches and lahars occur every few years to decades and are often related to rain-on-snow events. Lahars large enough to reach Baker Lake occur on a time scale of one every few decades to centuries and may or may not be triggered by an eruption. Lahars that are large enough to travel more than about 10 miles (15 km), seem to be related to eruptive activity and, like modest magmatic eruptions, are separated by several centuries to a few millennia.

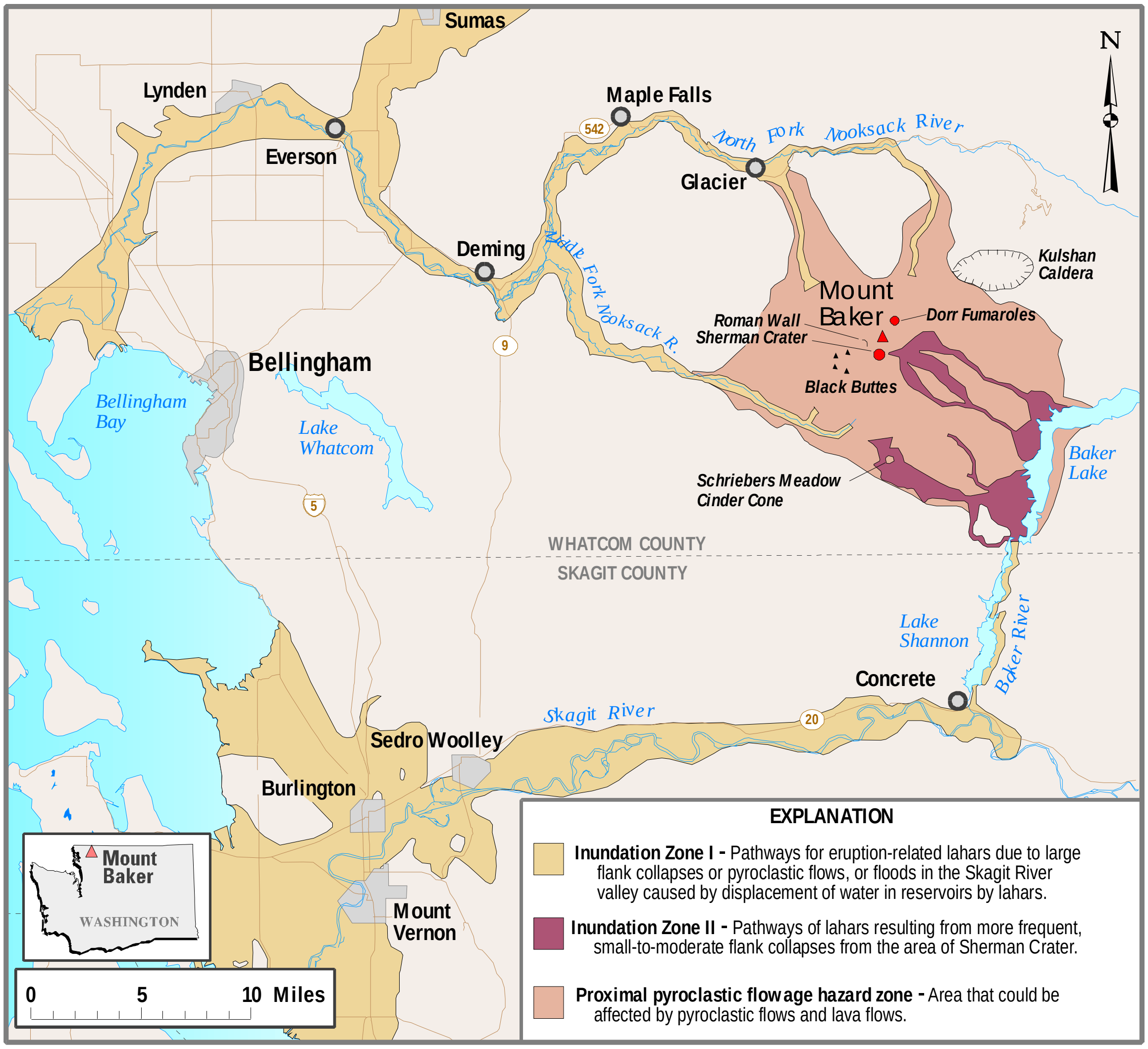


Figure 1: Areas at risk from lahars or pyroclastic flows during future eruptions of Mount Baker.

- Debris-avalanche or lahar material entering Baker Lake would displace an equivalent volume of water. If the volume of displaced water were large enough, it could overtop or destroy Upper Baker Dam and thus potentially overtop or destroy Baker Dam. In the case of overtopping (or less likely failure) of Baker dam, a flood or lahar would move down the Skagit River valley.
- A large lahar in any drainage around Mount Baker may aggrade river valleys and increase sediment yield, thus potentially exacerbating flooding problems for years or decades after the initial event has occurred.
- An eruption of Mount Baker may dust communities as far as 60 miles (100 km) or more downwind with about a third of an inch (a few millimeters) of volcanic ash, and pose a hazard to jet aircraft. Due to prevailing wind patterns, the most likely areas to be affected are to the northeast, east or southeast; however, areas affected by ash fall will depend upon wind patterns during an eruption. Residents should be aware that they are as likely to be affected by ash from another Cascade volcano, such as Mount St. Helens or Glacier Peak as they are from an eruption of Mount Baker.

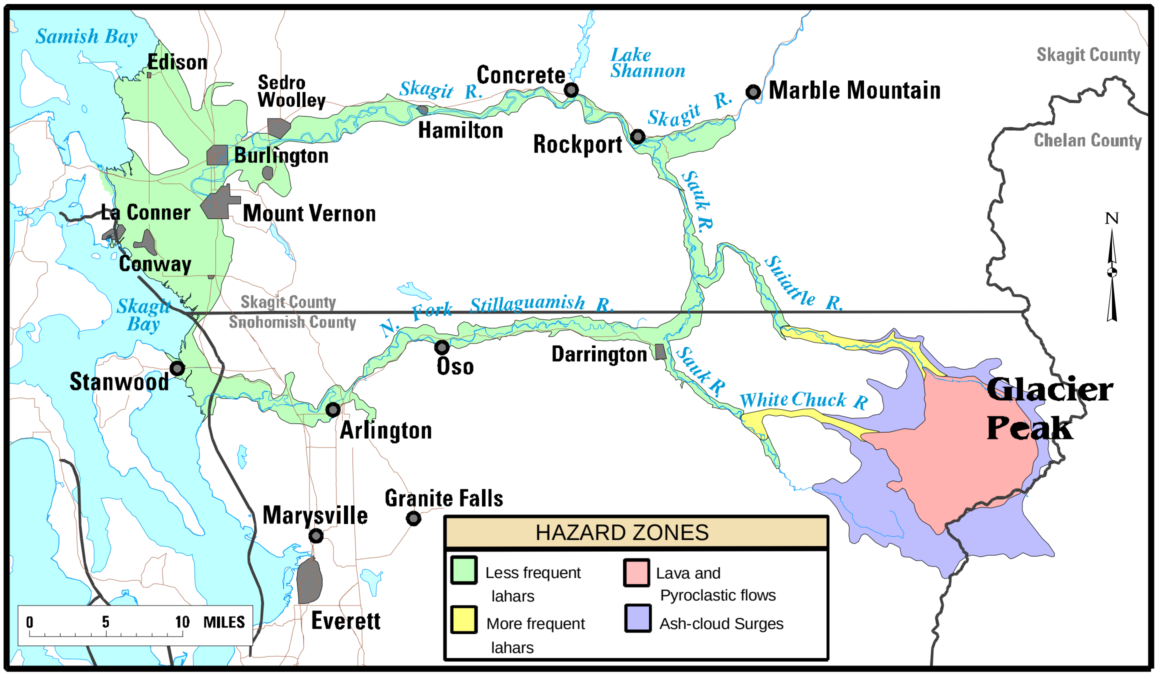


Figure 2: Areas at risk from lahars, pyroclastic flows, ash-cloud surges and associated phenomena

Glacier Peak

Unlike Mount Baker, Glacier Peak is not prominently visible from any major city. At 10,541 feet (3212 m) elevation, it is, next to Mount St. Helens, the shortest of the major Washington volcanoes. But its small size belies a violent past. Glacier Peak has produced larger and more explosive eruptions in post-glacial time than any other Washington volcano except Mount St. Helens.

In contrast to Mount Baker, whose most recent eruptions produced primarily lava flows, Glacier Peak's eruptions tend to produce highly explosive eruptions or lava domes that may collapse repeatedly to produce fast moving pyroclastic flows and lahars. Activity over the last 14,000 years has included:

- A series of large eruptions about 13,000 years ago spread ash across northern Idaho, Wyoming, Montana, and southern Alberta. Single eruptions during this period deposited as much as four inches (10 cm) of ash 60 miles (100 km) downwind.
- About 6,000 years ago, eruptions repeatedly produced lava domes on the north flank of the volcano that collapsed and filled the Suiattle River valley and its tributaries with pyroclastic-flow deposits.
- At least three smaller eruptions produced tephra during the past 5,900 years; the youngest of which occurred less than 300 years ago.
- Lahars have accompanied nearly all of these eruptions. During at least three post-glacial eruptive periods (about 13,000, 6,000, and 2,800 years ago) some lahars reached as far as the ocean. Lahars from the 13,000-yr eruptions extended to Puget Sound down the Stillaguamish River Valley, which at that time formed the outflow to the Suiattle and Sauk Rivers. Lahars from the 6,000- and 2,800-yr eruptions extended to the lower Skagit River and probably to the ocean.

- At least one lahar-producing eruptive episode has occurred since about 2,800 years ago, depositing debris as far downstream as the confluence of the White Chuck River and Sauk Rivers, and the lower Suiattle valley. No lahar deposits younger than ~2,800 yrs have been recognized farther downstream, although flooding and other effects of the lahars surely extended farther.

Potential future hazards

- Deposits of ash associated with major eruptions could extend across northeastern Washington, northern Idaho, Wyoming, Montana, and southern Alberta (Fig. 3). However, communities should be aware that if an eruption occurs during rare times when the wind blows from the east, then areas west of the volcano could be severely affected. Even minor amounts of ash could prove disruptive to air and ground transportation.

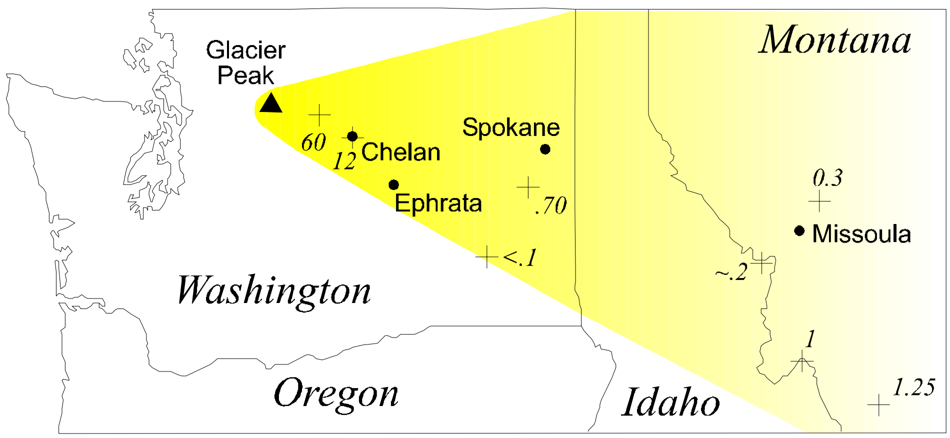


Figure 3: Cumulative thickness of ash (inches) deposited during eruptions from Glacier Peak approximately 13,000 years ago.

- Growth and repeated collapse of lava domes could generate pyroclastic flows on the flanks of the volcano. However, Glacier Peak is so remote that collapse of lava domes on the flanks of the volcano and even lahars in the upper White Chuck and Suiattle River Valleys would pose little threat of human casualties. However, ash falls associated with the pyroclastic flows may impact populated areas at greater distances from the volcano.
- In the years following eruptive episodes, volcanic debris could aggrade river valleys as far as Puget Sound, filling channels and promoting flooding (Fig. 4). Currently, all drainages are channeled into the Skagit valley. However, aggradation of the Sauk River near Darrington could divert the upper part of the Sauk River into the Stillaguamish, increasing the risk of floods and lahars to communities in the Stillaguamish River Valley.

Figure 4: Several cubic kilometers of tephra ejected by Mount Pinatubo in June 1991 was reworked by streams around the mountain during the following years. Above, lahars of Pinatubo ash along the Abacan River buried the town of Bacalor to depths of 15 feet in the town proper, and more than 30 feet in some outlying villages (photo by C.G. Newhall, USGS).

- The recurrence interval for lahars extending into the lower Sauk or Skagit River Valley is on the order of several thousand years. The recurrence interval for large ash-producing eruptions that could affect eastern Washington is of the same order.

THE ONSET OF CRISIS: MONITORING AND EVENT NOTIFICATION

Nearly all eruptions are preceded by measurable changes in seismicity, gas emission, ground deformation or other geophysical and geochemical parameters caused by magma forcing a path to the surface. The areas around Mount Baker and Glacier Peak are continuously monitored by the Pacific Northwest Seismograph Network (PNSN), which is jointly operated by the University of Washington and the USGS. The first indications of volcanic unrest at Mount Baker or Glacier Peak will likely be an increase in earthquake activity, and it will likely take days to weeks to decide whether the increase is the result of magma movement towards the surface or not.

In response to developing volcanic unrest, a USGS response team expects to:

1. ***Establish a temporary volcano observatory*** at or near an Emergency Operations Center in Whatcom, Skagit, or Snohomish County. The observatory will maintain close contact with emergency managers and will be sited to allow efficient daily helicopter access to the volcano. The primary function of the USGS response team is to monitor all volcanic developments and provide eruption-forecasting and hazard-assessment information to support decisions by public officials.
2. ***Install monitoring instruments*** to collect and analyze visual, seismic, lahar-detection, deformation, and gas-emission data. As an important element of redundancy, critical seismic data will be received and analyzed both at the University of Washington and the local temporary volcano observatory.

Warning time and duration of eruption: long or short?

At volcanoes around the world, the amount of warning time between the first appearance of volcanic unrest and the onset of a major, hazardous eruption has ranged from about a day, to years. At Redoubt Volcano in Alaska, increased steaming was noted in early November, 1989; but seismic activity remained low until 13 December, about 25 hours before the onset of a major explosive eruption. Three more explosive events on 15 December were followed by six months of dome growth and dome collapse until activity ceased in early summer of 1990. At Soufriere Hills Volcano on the island of Montserrat, British West Indies, the first seismic unrest in January 1992 preceded the first eruption by three years. The first small steam explosion in July 1995 was followed by the appearance of a lava dome in September of that year. Pyroclastic flows from the growing dome began spilling into surrounding valleys in March 1996, leading to the gradual destruction of Plymouth, the capital city, and surrounding towns and farmland over the next two years. Dome growth and periodic explosions continue at Montserrat.

For a variety of reasons, hazardous magmatic eruptions at Mount Baker or Glacier Peak will probably be preceded by weeks or more of unrest. Chief among those reasons is that Mount Baker and Glacier Peak have been dormant for centuries; the conduit systems that convey magma to the surface have solidified and will have to be fractured and reopened for the next magma to reach the surface. In the Cascade Mountains, two volcanoes have produced magmatic eruptions during the twentieth century. At Mount St. Helens, the climactic eruption of May 18, 1980, was preceded by increased seismicity, uplift, and steam eruptions that began in late March of that year. At Mount Lassen, small steam and ash explosions began on June 30th, 1914 and continued sporadically for almost a year before the onset of large magmatic eruptions in May, 1915.

Event Notification

Volcanic activity at Mount Baker or Glacier Peak may have dramatically different impacts depending on the type of eruption and the direction in which hazards (lahars or tephra plumes) are transported. Local agencies require information on hazards that affect nearby areas, whereas airlines and the Federal Aviation Administration require information on tephra plumes that can be hazardous to aircraft hundreds of miles from source. The information required by these two groups is not always the same, and therefore the U.S. Geological Survey, in cooperation with various agencies, has developed two hierarchies of alert levels; one directed toward emergency response on the ground and the other toward ash hazards to aircraft. Those two hierarchies are described below.

Notification for ground-based hazard

The USGS issues statements of ground-based hazards through the Washington Emergency Management Division (EMD), which transmits them, as appropriate, to state and federal agencies (including FAA, FEMA, National Weather Service), British Columbia (Provincial Emergency Program), adjacent states, and counties. The counties then transmit the notifications as appropriate to their own emergency-management agencies, cities, city-government organizations, special-purpose districts, and citizens.

Event notification for ground-based hazards may occur under two distinctly different circumstances: (1) in response to small events that are generally unexpected and short-lived; (2) in response to developing volcanic unrest that may culminate in hazardous volcanic activity. The former is handled through information statements, the latter through volcano alert levels.

Information Statement (Short -lived events, not necessarily volcanic)

Unusual events such as steam bursts, small avalanches, rock falls, minor mudflows, a small earthquake swarm, thunderstorms, and slash burnings often attract media and public interest and inquiry. Most such events are short-lived and some may be hazardous, but lack recognizable precursors that would provide time for warning. Most of these events do not suggest volcanic unrest or major flank instability that would warrant a crisis response. However, owing to public and media inquiries that result from such events, the USGS along with other involved agencies will attempt to verify the nature and extent of the event, and issue commentary as appropriate. Information statements may also be issued to provide commentary about notable events occurring within any volcano alert level during volcanic unrest.

Volcano Alert Levels

Volcano Alert Levels reflect the degree of concern and the anticipated imminence of hazardous volcanic activity. Alert-level notifications will be accompanied by explanatory text to clarify hazard implications as fully as possible. Updates may be issued to supplement any alert-level statement.

Alert-level assignments depend upon observations and interpretations of changing phenomena. Some volcanic events may not be preceded by obvious changes, or the observed changes may not be well understood; thus, surprises are possible, and uncertainty about timing and nature of anticipated events is likely. Alert levels are not always followed sequentially.

Notice of Volcanic Unrest *(first recognition of conditions that could lead to a hazardous event).*

This alert level is declared by the USGS when anomalous conditions are recognized that could lead to a hazardous volcanic event. The most likely such condition would be sustained, elevated seismicity, detected by the PNSN. A notice of volcanic unrest expresses concern about the potential for hazardous volcanic activity but does not imply imminent hazard. Among the possible outcomes are: (1) anomalous condition is determined not symptomatic of an eventual hazardous volcanic event, thus the notice is cancelled; (2) symptomatic activity wanes, leading to cancellation of the notice; (3) conditions indicate a progression toward hazardous volcanic activity, leading to issuance of a volcano advisory or volcano alert.

Volcano Advisory *(hazardous volcanic event is likely but not necessarily imminent)*

This alert level is declared by the USGS when monitoring and evaluation indicate that a hazardous volcanic event is likely but not necessarily imminent. This alert level is used to emphasize heightened concern about potential hazard. Among the possible outcomes are: (1) precursory activity wanes, leading either to cancellation of the advisory or to a downgrade to a notice of volcanic unrest; (2) conditions evolve so as to indicate that a hazardous volcanic event is imminent or underway, leading to issuance of a volcano alert. Volcano advisory statements will be updated as necessary, to clarify as fully as possible the USGS's understanding of the hazard implications.

Volcano Alert *(hazardous volcanic event appears imminent or is underway)*

This alert level is declared by the USGS when precursory events have escalated to the point where a hazardous volcanic event appears imminent or is underway. Depending upon further developments, a volcano alert may be maintained, downgraded or canceled. A volcano alert will indicate, in as much detail as possible, the time window, place, and expected impact of an anticipated hazardous events. Updated statements will provide information as dictated by evolving conditions.

Notification for ash hazard to aircraft

Tephra plumes from volcanic eruptions can travel hundreds or thousands of miles from their sources. Even when the concentration of ash is so low that it is of little interest or concern to populations on the ground, it can severely impact aircraft, especially large commercial jet aircraft. Consequently, NOAA, FAA, and USGS are jointly developing a separate plan for interagency communication about atmospheric ash hazards. Under this plan, the USGS will issue, to NOAA, FAA, and the appropriate Canadian agencies, separate notices about anticipated or existing atmospheric-ash hazards. Those notices will be given in the terms of the already-established color code:

- ***Green*** - Volcano is quiet; no eruption is anticipated.
- ***Yellow*** - Volcano is restless; eruption is possible but not known to be imminent.
- ***Orange*** - Small explosive eruption(s) either imminent or occurring; tephra plume(s) not expected to reach 25,000 feet (7,600 m) above sea level.
- ***Red***- Major explosive eruption imminent or occurring; large tephra plumes expected to reach at least 25,000 feet (7,600 m) above sea level.

CRISIS RESPONSE: ORGANIZATION AND RESPONSIBILITIES

Interagency Organizations

The overriding principle in a volcanic emergency is that that preservation of human life takes precedence over protection of property. Federal, State and/or local jurisdictional authorities may protect life and property by, among other actions, closing high-risk areas to public access, or evacuating local residents from hazard zones.

During a response, each agency and organization will provide resources and administrative support, and will act in accordance with the basic principles of the Incident Command System (ICS). County Emergency Management agencies (DEMs), the Washington State Emergency Management Division (EMD), and the Federal Emergency Management Agency (FEMA) have primary responsibilities for coordinating local, regional, State and Federal responses, respectively. In Canada, the Provincial Emergency Program (PEP) and Emergency Preparedness Canada (EPC) coordinate the response of British Columbia and Canada respectively for disasters that affect them. The responsibilities of Local, State, Provincial and Federal agencies are summarized in Table 1. The authorities under which these agencies operate are described in Appendix A.

Table 1: Responsibilities and contact information for FAC members.

Jurisdiction and its Responsibilities	Contact Information
LOCAL GOVERNMENT Local jurisdictions are responsible for the overall direction and control of emergency activities undertaken within their jurisdictional boundaries. Each county may activate an emergency operations center located at the address given to the right.	**Snohomish County** – Emergency Operation Center, 3509 109th Street SW, Everett, 425-423-7635. **Skagit County** – Consolidated Communication Center, 2911 East College Way, Suite B, Mount Vernon, 360-428-3250. **Whatcom County** - County Courthouse Basement, 311 Grand Avenue, Bellingham, 360-676-6681.
STATE GOVERNMENT The Governor, the Governor's cabinet, composed of the Executive Heads of State agencies or their representatives, and staff from the State Emergency Management Division, are responsible for the conduct of emergency functions and will exercise overall direction and control of state government operations.	**Washington State –** Emergency Operation Center, Camp Murray, Tacoma, Building 20, 800-258-5990

PROVINCIAL GOVERNMENT Coordination of provincial response and recovery would occur under the direction of the Provincial Emergency Program of British Columbia.	**Provincial Emergency Coordination Centre –** 455 Boleskine Road, Victoria, British Columbia, 800-363-3456
FEDERAL GOVERNMENT The **Federal Emergency Management Agency** (FEMA) is responsible for federal agency coordination and operation of the Regional Operation Center (ROC). The **U.S. Geological Survey** will conduct field operations, monitoring and provide advice to other agencies regarding the status of the volcano. The USGS may locate with an appropriate county. The **U.S. Forest Service,** Mount Baker-Snoqualmie National Forest, is responsible for management of lands within the National Forests and the Skagit Wild and Scenic River.	**FEMA ROC –** 130-228th Street S.W., Bothell, 425-487-4700 **U.S. Geological Survey**, Cascades Volcano Observatory, 5400 MacArthur Blvd., Vancouver, WA 98661, 360-993-8900. **U.S. Forest Service,** Mount Baker-Snoqualmie National Forest, 2105 State Route 20, Sedro Woolley, WA 98284 360-856-5700.
CANADIAN FEDERAL GOVERNMENT Canadian Federal response will be in support of provincial operations. Emergency Preparedness Canada would be responsible for federal agency coordination and is located at the Regional Emergency Operations Centre (REOC).	**EPC**. REOC P.O. Box 10000, Victoria, B.C. V8W3A5, 250-363-3621

In addition to the agencies and organizations that already exist with responsibility for preparededness, response, and recovery, two committees have been or will be formed specifically to deal with hazards from Mount Baker and Glacier Peak. These are the Mount Baker/Glacier Peak Facilitating Committee (FAC) and the Multi-Agency Coordinating Group (MAC) Responsibilities of the FAC, MAC, and of County Departments or Divisions of Emergency Management are illustrated in the following chart (Fig. 5), and described below.

Response Organization Coordination Diagram

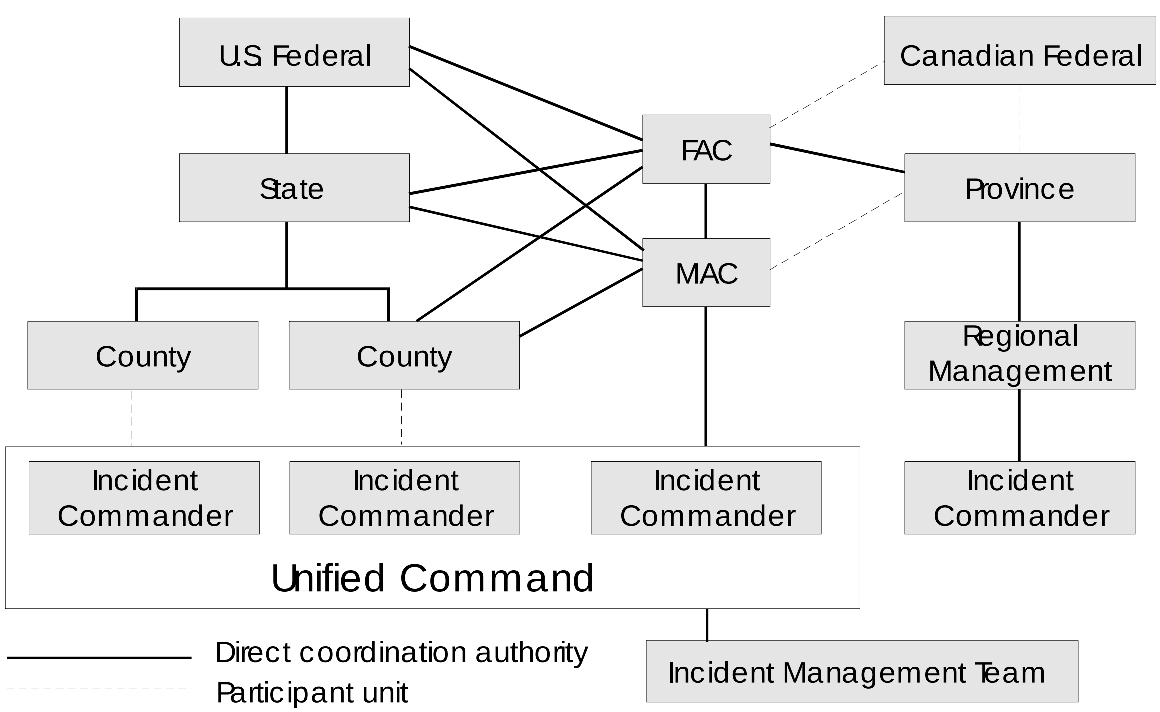


Figure 5: Flow chart of relationships between various agencies involved in unrest at Glacier Peak or Mount Baker.

Mount Baker/Glacier Peak Facilitating Committee (FAC)

The FAC has been established to maintain preparedness during times of volcanic quiescence and to determine appropriate levels of action when unrest begins and ends. It is made up of members from each jurisdiction with statutory responsibilities for emergency response (Table 2). Additional agencies (Associate Members in Table 2) may also attend meetings of the FAC. The FAC may be called together by any member who identifies a need for coordinated discussions. The FAC will be responsible for exercising this plan. The Washington State Emergency Management Division has the responsibility to assemble the FAC for an annual review of the plan. Responsibilities of the FAC before, during, and after a crisis is outlined in the Concept of Operations Section.

Table 2: Members and Associate Members of the FAC. See Table 1 for contact list for full members. Contact list for Associate Members is given in Appendix __.

Members shall include	Associate Members may include
Skagit County Department of Emergency Management	Washington State Patrol
Whatcom County Division of Emergency Management	FEMA, Region X
Snohomish County Department of Emergency Management	Emergency Preparedness Canada
Washington State Division of Emergency Management	National Park Service
Washington State Department of Natural Resources	Tribal Nations and/or First Nations
U.S. Geological Survey	Bureau of Indian Affairs
U.S. Forest Service	Geological Survey of Canada
Provincial Emergency Program (British Columbia)	Other concerned jurisdictions, agencies and/or organizations

The Multi-Agency Coordinating Group (MAC)

The MAC will operate only during crisis, and may be given the responsibility of coordinating and supporting actions such as warnings, road blocks, air operations (including space restrictions), emergency public information, and search and rescue. The MAC may also serve as a clearinghouse for information from the various agencies. The MAC should be composed of representatives from each jurisdiction with responsibilities for resource allocation or emergency response operations. If the incident involves Mount Baker, Snohomish County Emergency Management, upon request, will establish and administer the MAC on behalf of the impacted jurisdictions. If the incident involves Glacier Peak, Whatcom County Emergency Management, upon request, will establish and administer the MAC. The members of the MAC shall have the authority to make decisions that integrate facilities, personnel, procedures, and communications into a common system.

During a crisis either the FAC and/or MAC may choose to establish a Joint Information Center (JIC) in order to disseminate information to the press and the public on ongoing events. The structure of the JIC is given in Appendix E.

Incident Management Teams (IMT's)

Once activities have exceeded the management capabilities of local resources, a Washington State Interagency Incident Management Team (IMT) may be activated. The IMT shall be responsible for the coordinated management of the incident and implementing the objectives of the local jurisdiction and (or) the MAC. The IMT will carry out the direction of the Unified Command, and may be activated by contacting the State Emergency Management Division.

Agency Responsibilities

Divisions or Departments of Emergency Management

During a crisis, information about the status of a volcano would normally be transmitted from the USGS through the Washington State EMD to the MAC and to county Divisions or Departments of Emergency Management (DEMs). The DEMs would then relay the information to local jurisdictions and agencies. As needed, the county DEMs would:

a) Implement Emergency Operation Plans, maintain and activate Emergency Operations Centers.
b) Provide local public warnings and information.
c) Activate the Emergency Alert System (EAS).
d) Assist Incident Commander(s).
e) Participate in establishing a unified command structure.
f) Establish a regional coordination center.
g) Provide local Public Information Officers (PIO's) for a JIC.
h) Assist the U.S. Geological Survey in establishing a Field Volcano Observatory.
i) Provide for the welfare of citizens impacted by a volcanic event.
j) Initiate and coordinate local declarations of emergency or requests for assistance from state and/or federal resources.
k) Develop crisis-response plans in their own counties.
l) Provide information and training on volcanic-hazard response to emergency managers and the public.
m) Assess volcanic risk as part of a larger Hazard Identification and Vulnerability Analysis (HIVA).

State Military Department, Emergency Management Division

EMD, through its 24 hour Emergency Operations Center (EOC), is responsible for providing alert and warning to local jurisdictions potentially impacted by volcanic unrest. Additionally EMD will notify specific state and federal agencies that have a response role during a volcanic event. The EOC would then work with other entities in order to coordinate resources to support local and state agency response. In support of this plan EMD's responsibilities include:

a) Coordinating the acquisition and distribution of resources to support response
b) Developing plans and procedures.
c) Acting as the central point of contact for local government requests for specific State and Federal disaster related assets and services.
d) Activating and staffing the Washington State Emergency Operations Center (EOC)
e) Activating the State Emergency Alert System (EAS) to advise the public of the existence of emergency conditions and protective actions that should be taken.
f) Activate the Washington Emergency Information Center (WEIC) to provide event related public information
g) Coordinating with the Federal Government on supplemental disaster assistance necessary to preserve lives and property, and on recovery assistance necessary to restore damaged areas to pre-disaster condition.
h) Activating, if necessary, the Washington State- British Columbia Cooperative Agreement.
i) Deploying State Liaison Officers to affected jurisdictions.

Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) roles and responsibilities during a disaster and or an emergency are governed by the Robert T. Stafford Disaster Assistance and

Emergency Relief Act, as amended, 42 USC 5121, et seq., and the Federal Response Plan (FRP) for Public Law 93-288, as amended. The primary responsibility of FEMA is to coordinate and deliver assistance and support to state and local governments when requested. This request is typically through the governor as a Request for a Presidential Declaration of Disaster. A volcanic eruption would be handled in much the same way as any natural disaster. FEMA's responsibilities include:

a) Coordinating Federal level emergency planning, management, mitigation and assistance functions of Federal agencies in support of Sate and local efforts.
b) Providing and maintaining the Federal and State NAWAS Warning Circuits.
c) Providing FEMA liaison staff to the FAC, MAC and the State EOC.
d) Following a Presidential Declaration:
    1. Establishing a Disaster Field Office.
    2. Coordinating public information activities for all federal agencies and disseminating to news media.
    3. Coordinating State requests for Federal or military assistance.
    4. Coordinating Federal assistance operations

United States Geological Survey

The USGS Volcano Hazards Program seeks to lessen the harmful impacts of volcanic activity by monitoring active and potentially active volcanoes, assessing their hazards, responding to volcanic crises, and conducting research on how volcanoes work. USGS responsibilities include:

a) Issuing timely warnings of potential geological hazards to responsible emergency-management authorities and the populace affected.
b) Monitoring volcanic unrest, tracking its development, forecasting eruptions, and evaluating the likely hazards
c) Deploying staff and monitoring equipment during times of volcanic crisis.
d) Establishing a temporary volcano observatory located so as to provide ready access to the volcano for the USGS hazard-assessment team and ready access to the hazard-assessment team for the emergency managers (Appendix D).

U.S. Forest Service

The Forest Service manages public lands on and around both Glacier Peak and Mount Baker. Authorities include land management responsibility related to use, management and protection of these lands. Roles and responsibilities during a disaster or emergency include protection of life, property and national forest resources. Control of access and use of national forest is regulated by the U.S. National Forest in coordination with adjoining landowners and agencies.

Provincial Emergency Program (British Columbia)

The role of the Provincial Emergency Program with regard to volcanic eruptions in British Columbia or Washington State is to:

a) Receive information from the Geological Survey of Canada, or the U.S. Geological Survey.
b) Disseminate timely and accurate information to all Federal and Provincial agencies as and when required.
c) Provide timely and accurate information to those communities which may be at risk - issue warnings.
d) Coordinate the Provincial Governments response to and recovery from volcanic eruptions.
e) Manage the media, in relation to the Provincial Government involvement.

Note: All the above activities will be managed/coordinated through the Emergency Coordination Centre (ECC). The ECC is staffed on a 24/7 basis, 365 days a year.

How to cope: Logistical problems during volcanic crises

Volcanic crises pose problems to communities that may not exist during other types of catastrophes. Below are some problems that are inherent in volcanic crises. Appendix F lists some publications describing case studies.

Uncertainty. Once a volcano shows signs of life, it is not clear whether or when it could produce a major hazardous eruption. In 1975, Mount Baker increased the steam output from its summit crater for a few months, then fell back to dormancy with no indication of magma movement. Popocatepetl Volcano near Mexico City has periodically threatened nearby communities since 1993, causing nearby villagers to evacuate more than once, only to return after large eruptions failed to take place. At St. Pierre in Martinique (French West Indies), local authorities in 1902 opted not to evacuate in spite of four months of seismicity and steam explosions at Mount Pelée, five miles to the north. On May 8, a major eruption produced a pyroclastic flow that destroyed the town and killed 29,000 residents. In 1982, in response to earthquake swarms and uplift at Long Valley, California, the USGS issued a low-level forecast of a possible eruption. Activity subsided and the USGS was branded the "U.S. Guessing Society" by local residents. Authorities in these circumstances are generally in a "no-win" situation. Their best hope of maintaining public trust is to convey the uncertainty inherent in volcanic crises, and to maintain extremely close and open relations with community leaders.

Controlling access. During the crisis at Mount St. Helens in March and April, 1980, volcano-watchers would bypass road blocks to view the volcano, stage illegal climbs to the summit, even land helicopters at the summit to film commercials. The difficulty in controlling access to the mountain was compounded by the checkerboard pattern of public and private land ownership, and the extensive network of logging roads.

CONCEPT OF OPERATION

This plan is based on the premise that each agency with responsibilities for preparedness, response, or recovery activities has, or will develop, an individual operations plan or Suggested Operating Guidelines (SOG) that covers its organization and emergency operations. This plan establishes a mechanism for coordination of each agency's efforts.

The Concept of Operations can be defined with respect to three phases of volcanic activity: (1) ***preparedness*** (2) ***response*** and (3) ***recovery.***

Preparedness Phase (when volcanoes are in repose)

a. The FAC shall:
   1. Prepare emergency plans and programs to ensure continuous readiness and response capabilities. The FAC shall meet yearly to:
      a. Coordinate, write, revise and exercise this volcano response coordination plan.
      b. Develop and evaluate alert and warning capabilities for the volcanic hazard risk areas
      c. Review public education and awareness requirements and implement an outreach program on volcano hazards.

Response Phase

a. Members of the FAC shall:
   1. Meet whenever any member deems it necessary.
   2. Share information on the current activity of Mount Baker and/or Glacier Peak and coordinate data relating to hazard assessments, evaluations and analysis.
   3. Assess the need to activate the MAC Group and activate the MAC as necessary, or;
   4. Coordinate any needed public information or establish a JIC for this purpose.

b. Upon activation, the MAC shall:
   1. Facilitate accurate and timely collection and exchange of regional incident information.
   2. Coordinate regional objectives, priorities and resources.
   3. Analyze and anticipate future agency/regional resource needs.
   4. Coordinate regional public information through a JIC.
   5. Communicate MAC decisions to jurisdictions/agencies.
   6. Review need for other agencies involvement in the MAC.
   7. Provide necessary liaison with out-of-region facilities and agencies as appropriate.
   8. Designate regional mobilization centers as needed, in coordination with the IMT.
   9. Coordinate damage assessment and evaluation.
      a. Evaluate disaster magnitude and local disaster assistance and recovery needs.
      b. Obtain detailed data on casualties, property damage, resources status.

Recovery Phase

When hazardous geologic activity has subsided to a point where reconstruction and restoration activities may be initiated, even when the mountain is still in eruptive state, recovery efforts may be initiated and carried out.

a. In addition to the functions previously noted, the MAC shall:
   1. Coordinate recovery and reconstructive efforts.
   2. Assist Incident Commander(s) in demobilization.
   3. Continue to coordinate the collection and dissemination of disaster information including informing the public about hazardous conditions, health, sanitation and welfare problems, and need for volunteers
   4. Determine when to terminate the MAC operations.

b. The FAC shall:
   1. Conduct an After Action Review of the event and make changes to the plan as necessary.

Organization and responsibilities according to levels of unrest

Following are the detailed responsibilities and tasks of jurisdictions and agencies at the various levels of notification.

A. Following a Notice of Volcanic Unrest:

1. Local jurisdictions and Agencies:

- Convene the FAC.
- Review plans and procedures for response to the Volcanic Hazards threat.
- Designate individuals who will be responsible for filling positions in the local ICS and/or Unified Command Structure as requested.
- Provide orientation sessions on updated plans and organizational structure.
- Update personnel lists.
- Update call-up procedures for all staff.
- Conduct briefings as needed.

2. State EMD

- Convene the FAC.

- Review internal plans and procedures.
- Implement notifications.
- Provide technical assistance to local jurisdictions.
- Coordinate with other Emergency Support Functions (ESF) agencies that will provide assistance.
- Coordinate mutual aid agreements with British Columbia and neighboring states.
- Evaluate the need for assistance from other agencies.
- Evaluate resource requirements.
- Issue advisories and state level policies in consultation with the FAC.
- Conduct hazard specific training.
- Conduct briefings as needed.

3. USGS

- Convene the FAC.
- Monitor the status of the volcano and determine the need for additional instrumentation.
- Issue alert-level notifications and updates.
- Consider establishing field observatory.

4. National Park Service and U.S. Forest Service

- Convene the FAC.
- Provide public education
- Evaluate need for access control and implement as needed.
- Evaluate need for air space controls and implement as needed.
- Authorize placement of additional instrumentation as needed.

5. British Columbia PEP

- Convene the FAC.
- Review and update the Provincial Volcano Response Plan.
- Receive information from the USGS or the Geological Survey of Canada.
- Disseminate information to local governments, provincial ministries and federal departments in British Columbia.

6. Emergency Preparedness Canada

- Disseminate information to other federal organizations and other provinces as required.
- Ensure liaison with FEMA Region X and other U.S. agencies as needed.

7. FAC

- Discuss and evaluate developing events
- Review this Plan
- Disseminate public information
- Consider establishing the MAC

B. During a period of increased volcanic unrest (Volcano Advisory):

1. Local Jurisdictions and Agencies:

- Establish local Incident Command and consider the possible need for Unified Command with other jurisdictions.
- Conduct surveys on resource availability and reaffirm prior commitments.
- Test communications systems and assess communication needs.
- Begin procurement of needed resources.
- Assign PIO's to the JIC as needed.
- Provide briefings and direction to all response personnel.
- Request all assigned personnel to stand by for orders to activate emergency plan.
- Coordinate support requirements for USGS Field Observatory.
- Take readiness and precautionary actions to compress response time and to safeguard lives, equipment and supplies.

2. State EMD

- Implement plans for state level communications support within the affected area.
- Consider coordinating joint public education programs.
- Increase, as needed, the staffing at the EOC.
- Consider establishing a Washington Emergency Information Center (WEIC) and support local government with PIO information.
- Ensure state agencies are alerted to potential problems and review their operational responsibilities.
- Assign liaison(s) to local unified command upon request.

3. USGS

- Establish field observatory if not already established

4. British Columbia PEP

- Issue warnings to communities at risk.
- Activate regional incident management teams.
- Conduct hazard-specific training and exercises.

5. Emergency Preparedness Canada

- Coordinate support by federal agencies to the provincial preparedness efforts.

6. FAC

- Establish MAC if not already established.
- Consider requesting the participation of the Mobilization Incident Commander (MIC) of the Incident Management Team (IMT).

C. Upon receipt of official notification that a volcanic eruption or *lahar* is imminent or occurring (Volcano Alert):

1. Local Jurisdictions and Agencies:

- Fully mobilize all assigned personnel and activate all or part of the Mt. Baker/Glacier Peak Coordination Plan.
- Activate Comprehensive Emergency Management Plans.
- Continually broadcast emergency public information.
- In accordance with ICS procedures, direct and control emergency response activities in each jurisdiction.
- Ensure MAC is adequately staffed and equipped.
- Consider requesting state mobilization and possible activation of an IMT.

2. State EMD

- Activate State Comprehensive Emergency Management Plan
- Coordinate the state response to the emergency.
- Coordinate interstate mutual aid.
- Coordinate federal response.

3. FAA

- Issue airspace alert warning of restricted or prohibited space.
- Coordinate use of affected airspace by aircraft involved in emergency response.

4. FEMA

- Activate Federal Response Plan
- Administer disaster relief funding following declaration of an emergency or major disaster by the President.
- Coordinate Federal response

5. USGS

- Monitor the status of seismic and geologic activity in the hazard area.
- Issue alert-level notifications and updates.
- Provide liaison to the MAC to provide ongoing information and advice.

6. National Park Service and U.S. Forest Service

Implement plans to participate directly in the following coordinated response operations within the affected areas:

- Fire
- Evacuation
- Security
- Access Control
- Search and Rescue
- Alerting and Notification
- Provide personnel for Unified Command Structure

- Provide representation to the MAC
- Support operations, logistics, and planning functions with personnel and resources.

7. **British Columbia PEP**
   - Coordinate the provincial response to the emergency.
   - Coordinate response with the State of Washington where appropriate.

8. **Emergency Preparedness Canada**
   - Ensure federal responsibilities are implemented and sustained.
   - Provide national level support to the provincial response.

9. **MAC**
   - Coordinate support for Unified Command

ENSURING PREPAREDNESS

No living person in the Northwest has experienced an eruption at Mount Baker or Glacier Peak; nor has any local official or scientist yet dealt with crises at either of these volcanoes. When the next volcanic crisis strikes, it is vital that public officials and citizens alike know what actions to take to protect life and property.

Residents of western Washington and southwestern British Columbia are the focus of an outreach program developed in partnership by the USGS, universities, and government agencies. The goals of this program include strengthening the educational system's coverage of volcanic hazards, history and risks, both by offering better classroom materials and by providing special training and information for teachers. Another emphasis includes taking the message about vulnerability to events from Mount Baker and Glacier Peak "on the road" through public presentations.

Of great importance is the need for emergency managers, local officials and scientists to be familiar and comfortable with their roles in the event of volcanic unrest. Development of specific plans like this one is only a first step. The plan must be reviewed regularly and revised to meet the changing needs of the region's rapidly growing communities. Although a volcanic eruption in the Cascades may be a once-in-a- lifetime event, those individuals charged with public safety must train themselves and their organizations through exercising the plan in order to ensure that crisis coordination will be smooth and seamless.

Plan Limitation

No plan, including this one, can guarantee a perfect disaster response. Officials must be prepared for the unpredictable nature of volcanoes when determining how to respond to crises. It may be necessary, for example, to adopt a defensive posture for an indefinite time due to a lack of verifiable and/or conclusive information, a lack of adequate resources, or danger to responders. If some disruptive response has been carried out but no major eruption or collapse has followed, responders may have the difficult task of determining when to order a return to normal operations.

When a major catastrophic event does occur at Mount Baker or Glacier Peak, it could overwhelm even the most extensive response preparations. Some volcanic eruptions, combined with extreme weather, have decimated instrument networks and damaged transportation, communications, and warning systems so thoroughly as to cripple (at least temporarily) any crisis response.

APPENDIX A: AUTHORITIES

Federal United States

Public Law 93-288 Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1974
Public Law 920 Federal Civil Defense Act of 1950 as amended
Public Law 96-342 The Improved Civil Defense Act of 1980
Public Law 84-99 Flood Control and Coastal Emergencies
Federal Response Plan 1999
Flood Control Act of 1950
Department of Transportation Act of 1966
Federal Aviation Administration Act of 1958
Federal Energy Regulatory Commission Order 122

Federal Canada

Emergencies Act of 1988
Emergency Preparedness Act of 1988

State of Washington

RCW 38.08 Powers and Duties of the Governor
RCW 38.52 Emergency Management
RCW 38.54 State Fire Service Mobilization
RCW 43.06 Governor's Emergency Powers Act
WAC 118 Emergency Management
WAC 296 Washington Industrial Safety and Health Act
Washington State Comprehensive Emergency Management Plan
Memorandum of Cooperation between the Province of British Columbia and the State of Washington of 1981

Province of British Columbia

Emergency Program Act of 1996 and its regulations of 1993

Local

Mutual Aid Agreement for Whatcom, Skagit, Snohomish and San Juan Counties
Northwest Region Fire Mobilization Plan

Skagit County Department of Emergency Management

Skagit County Resolution # 8438
Ordinance # 8859 – Establishment of Joint Emergency Management Council
Agreement by County/Cities for a Joint Emergency Management Council
Skagit County Comprehensive Emergency Management Plan

Whatcom County Division of Emergency Management

Whatcom County Comprehensive Emergency Management Plan
Interlocal Cooperative Agreement for Emergency Management
Whatcom County Charter
Whatcom County Code 2.40-Emergency Management

Snohomish County Department of Emergency Management

Snohomish County Comprehensive Emergency Management Plan
Snohomish County Department of Emergency Management Bylaws
Snohomish County Code Chapter 2.36 * Emergency Services

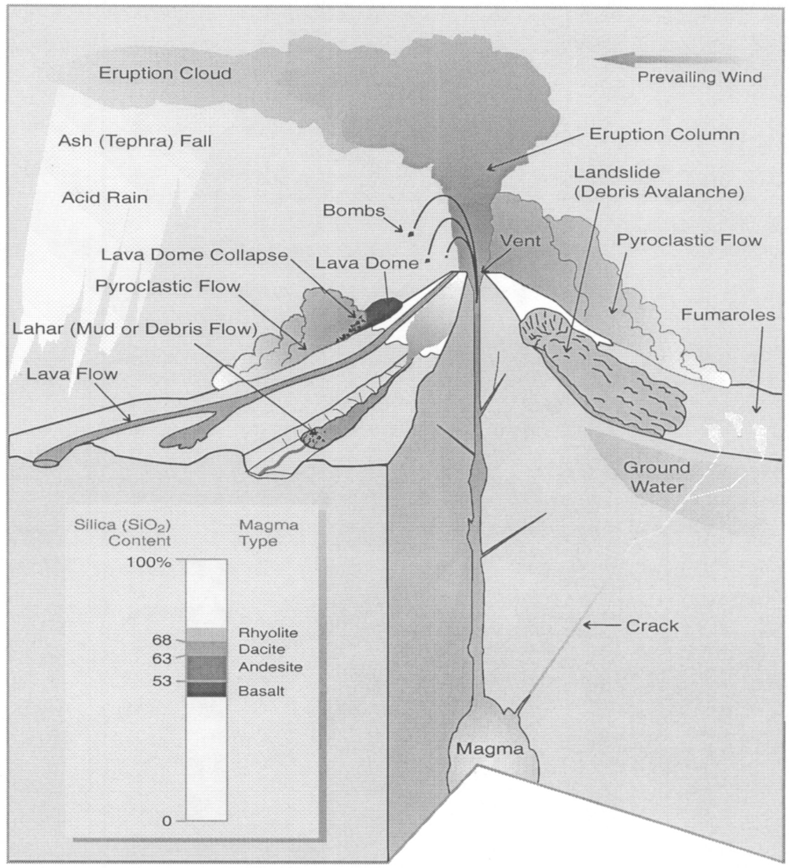
APPENDIX B: USGS FACT SHEET

REDUCING THE RISK FROM VOLCANO HAZARDS

What are Volcano Hazards?

Volcanoes give rise to numerous geologic and hydrologic hazards. U.S. Geological Survey (USGS) scientists are assessing hazards at many of the almost 70 active and potentially active volcanoes in the United States. They are closely monitoring activity at the most dangerous of these volcanoes and are prepared to issue warnings of impending eruptions or other hazardous events.

More than 50 volcanoes in the United States have erupted one or more times in the past 200 years. The most volcanically active regions of the Nation are in Alaska, Hawaii, California, Oregon, and Washington. Volcanoes produce a wide variety of hazards that can kill people and destroy property. Large explosive eruptions can endanger people and property hundreds of miles away and even affect global climate. Some of the volcano hazards described below, such as landslides, can occur even when a volcano is not erupting.



Volcanoes produce a wide variety of natural hazards that can kill people and destroy property. This simplified sketch shows a volcano typical of those found in the Western United States and Alaska, but many of these hazards also pose risks at other volcanoes, such as those in Hawaii. Some hazards, such as lahars and landslides, can occur even when a volcano is not erupting. (Hazards and terms in this diagram are highlighted in bold where they are discussed in the text below.)

Eruption Columns and Clouds

An explosive eruption blasts solid and molten rock fragments (**tephra**) and volcanic gases into the air with tremendous force. The largest rock fragments (**bombs**) usually fall back to the ground within 2 miles of the **vent**. Small fragments (less than about 0.1 inch across) of volcanic glass, minerals, and rock (**ash**) rise high into the air, forming a huge, billowing **eruption column**.

Eruption columns can grow rapidly and reach more than 12 miles above a volcano in less than 30 minutes, forming an **eruption cloud**. The volcanic ash in the cloud can pose a serious hazard to aviation. During the past 15 years, about 80 commercial jets have been damaged by inadvertently flying into ash clouds, and several have nearly crashed because of engine failure. Large eruption clouds can extend hundreds of miles downwind, resulting in **ash fall** over enormous areas; the wind carries the smallest ash particles the farthest. Ash from the May 18, 1980, eruption of Mount St. Helens, Washington, fell over an area of 22,000 square miles in the Western United States. Heavy ash fall can collapse buildings, and even minor ash fall can damage crops, electronics, and machinery.

Volcanic Gases

Volcanoes emit gases during eruptions. Even when a volcano is not erupting, **cracks** in the ground allow gases to reach the surface through small openings called **fumaroles**. Ninety percent of all gas emitted by volcanoes is water vapor (steam), most of which is heated **ground water** (underground water from rainfall and streams). Other common volcanic gases are carbon dioxide, sulfur dioxide, hydrogen sulfide, hydrogen, and fluorine. Sulfur dioxide gas can react with water droplets in the atmosphere to create **acid rain**, which causes corrosion and harms vegetation. Carbon dioxide is heavier than air and can be trapped in low areas in concentrations that are deadly to people and animals. Fluorine, which in high concentrations is toxic, can be adsorbed onto volcanic ash particles that later fall to the ground. The fluorine on the particles can poison livestock grazing on ash-coated grass and also contaminate domestic water supplies. ⇨

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Cataclysmic eruptions, such as the June 15, 1991, eruption of Mount Pinatubo (Philippines), inject huge amounts of sulfur dioxide gas into the stratosphere, where it combines with water to form an aerosol (mist) of sulfuric acid. By reflecting solar radiation, such aerosols can lower the Earth's average surface temperature for extended periods of time by several degrees Fahrenheit (°F). These sulfuric acid aerosols also contribute to the destruction of the ozone layer by altering chlorine and nitrogen compounds in the upper atmosphere.

Lava Flows and Domes

Molten rock (**magma**) that pours or oozes onto the Earth's surface is called lava and forms **lava flows**. The higher a lava's content of **silica** (silicon dioxide, SiO_2), the less easily it flows. For example, low-silica **basalt** lava can form fast-moving (10 to 30 miles per hour) streams or can spread out in broad thin sheets up to several miles wide. Since 1983, Kilauea Volcano on the Island of Hawaii has erupted basalt lava flows that have destroyed more than 200 houses and severed the nearby coastal highway.

In contrast, flows of higher-silica **andesite** and **dacite** lava tend to be thick and sluggish, traveling only short distances from a vent. Dacite and **rhyolite** lavas often squeeze out of a vent to form irregular mounds called **lava domes**. Between 1980 and 1986, a dacite lava dome at Mount St. Helens grew to about 1,000 feet high and 3,500 feet across.

Pyroclastic Flows

High-speed avalanches of hot ash, rock fragments, and gas can move down the sides of a volcano during explosive eruptions or when the steep side of a growing **lava dome collapses** and breaks apart. These **pyroclastic flows** can be as hot as 1,500°F and move at speeds of 100 to 150 miles per hour. Such flows tend to follow valleys and are capable of knocking down and burning everything in their paths. Lower-density pyroclastic flows, called pyroclastic surges, can easily overflow ridges hundreds of feet high.

The climactic eruption of Mount St. Helens on May 18, 1980, generated a series of explosions that formed a huge pyroclastic surge. This so-called "lateral blast" destroyed an area of 230 square miles. Trees 6 feet in diameter were mowed down like blades of grass as far as 15 miles from the volcano.

Volcano Landslides

A **landslide** or **debris avalanche** is a rapid downhill movement of rocky material, snow, and (or) ice. Volcano landslides range in size from small movements of loose debris on the surface of a volcano to massive collapses of the entire summit or sides of a volcano. Steep volcanoes are susceptible to landslides because they are built up partly of layers of loose volcanic rock fragments. Some rocks on volcanoes have also been altered to soft, slippery clay minerals by circulating hot, acidic ground water. Landslides on volcano slopes are triggered when eruptions, heavy rainfall, or large earthquakes cause these materials to break free and move downhill.

At least five large landslides have swept down the slopes of Mount Rainier, Washington, during the past 6,000 years. The largest volcano landslide in historical time occurred at the start of the May 18, 1980, Mount St. Helens eruption.

The town of Weed, California, nestled below 14,162-foot-high Mount Shasta, is built on a huge debris avalanche that roared down the slopes of this volcano about 300,000 years ago. This ancient landslide (brown on inset map; arrows indicate flow directions) traveled more than 30 miles from the volcano's peak, inundating an area of about 260 square miles. The upper part of Mount Shasta volcano (above 6,000 feet) is shown in dark green on the map.

Lahars

Mudflows or **debris flows** composed mostly of volcanic materials on the flanks of a volcano are called **lahars.** These flows of mud, rock, and water can rush down valleys and stream channels at speeds of 20 to 40 miles per hour and can travel more than 50 miles. Some lahars contain so much rock debris (60 to 90% by weight) that they look like fast-moving rivers of wet concrete. Close to their source, these flows are powerful enough to rip up and carry trees, houses, and huge boulders miles downstream. Farther downstream they entomb everything in their path in mud.

Historically, lahars have been one of the deadliest volcano hazards. They can occur both during an eruption and when a volcano is quiet. The water that creates lahars can come from melting snow and ice (especially water from a glacier melted by a pyroclastic flow or surge), intense rainfall, or the breakout of a summit crater lake. Large lahars are a potential hazard to many communities downstream from glacier-clad volcanoes, such as Mount Rainier.

To help protect lives and property, scientists of the USGS Volcano Hazards Program maintain a close watch on the volcanic regions of the United States, including the Pacific Coast States, Wyoming, Hawaii, and Alaska. This ongoing work enables the USGS to detect the first signs of volcano unrest and to warn the public of impending eruptions and associated hazards.

Bobbie Myers, Steven R. Brantley, Peter Stauffer and James W. Hendley II

Graphic design by

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COOPERATING ORGANIZATIONS

Alaska Div. of Geological and Geophysical Surveys
Federal Aviation Administration
National Oceanic and Atmospheric Administration
National Park Service
National Weather Service
U.S. Dept. of Agriculture, U.S. Forest Service
University of Alaska
University of Hawaii
University of Utah
University of Washington

For more information contact:
U.S. Geological Survey
Cascades Volcano Observatory
5400 Mac Arthur Blvd., Vancouver, WA 98661
Tel: (360) 696-7693, Fax: (360) 696-7866
e-mail: cvo@usgs.gov
URL: http://vulcan.wr.usgs.gov/

U.S. Geological Survey Fact Sheet 002-97
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APPENDIX C: GLOSSARY OF ACRONYMS

CVO: Cascades Volcano Observatory

DEM: Department (or Division) of Emergency Management

DFO: Disaster Field Office

DoD: Department of Defense

EAS: Emergency Alert System

ECC: Emergency Coordination Center

EMD: Emergency Management Division

EOC: Emergency Operation Center

EPA: Environmental Protection Agency

EPC: Emergency Preparedness Canada

ERT: Emergency Response Team

ESF: Emergency Support Function

FAA: Federal Aviation Administration

FAC: Facilitating Committee

FCO: Federal Coordinating Officer

FEMA: Federal Emergency Management Agency

FRP: Federal Response Plan

HIVA**:** Hazard Identification Vulnerability Assessment

ICS: Incident Command System

IMT: Incident Management Team

JIC: Joint Information Center

MAC: Multi-Agency Coordinating Group

MIC: Mobilization Incident Commander

NAWAS : National Warning System

NOAA: National Oceanic Atmospheric Administration

PEP: Provincial Emergency Program

PIO: Public Information Officer

PNSN: Pacific Northwest Seismographic Network

REOC: Regional Emergency Operation Centre

ROC: Regional Operation Center

SAR: Search and Rescue

SCO: State Coordinating Officer

SOG: Suggested Operating Guidelines

USGS: U.S. Geological Survey

WEIC: Washington Emergency Information Center

APPENDIX D: REQUIREMENTS FOR SITING A FIELD VOLCANO OBSERVATORY

The following is a rough guide to USGS requirements for a field observatory in, or close to, an established EOC. There is room for negotiation on these requirements. For example, if necessary, the USGS could set up operations room in a temporary structure (trailer?) in the parking lot and lease nearby office space for staff. The bottom line is: the USGS can probably adapt to most situations, especially for the first few weeks of any crisis.

Space requirements:

Space requirements can be separated into 5 areas; (1) Roof or tower space for mounting radio-communication antennas, (2) an "Operations" room that would be the focus of the real-time monitoring activities and coordinating field work, (3) an area where staff could set up desks and numerous computers for data analysis, preparation for field activities, and hold staff meetings, (4) storage space for items such as batteries or helicopter sling equipment, and (5) a media area separate from the other work areas.

- ***Antennas***. Real-time data from the volcano will be radio-telemetered to our field observatory. We will need space to mount approximately 10 yagi antennas, minimum of 4 ft. separation between antennas, line-of-sight to the volcano or to our repeaters, and within 100 feet of Operation room.
- ***Operations room.*** Approximately 300 sq. ft: All data are funneled into the operations room for acquisition and display. Also in Operations is the VOCOM radio for communication with field crews and phone lines for both voice and data. Space requirements for Operations should also take into account that it will be available at slow times for media photo opportunities and backdrops for interviews. (This need may be furnished by the JIC operations area)
- ***Staff office area***. Approximately 400 sq. ft: Staff will use this not only for office work, but also to store some field supplies, rock samples, equipment, etc.. It should be sufficiently large to contain some chairs and desks or tables, and still have room to hold a meeting of 15-20 people.
- ***Storage space.*** Approximately 300 sq. ft. A secure area for field equipment and supplies such as batteries, concrete, water jugs. etc., that is separate from staff and operation areas. This may be obtained through a commercial vendor, but would need to be nearby.
- ***Media briefings.*** We expect a room suitable for media briefings will already be in place or can be quickly found. The more physically separated from operations and staff offices the better.

Communication requirements:

- Six standard voice phone lines (1 for fax, 2 hotlines, 1 for recorded volcano information, and 2 for normal use)

- Two standard lines for data, either dialing into the USGS computer network or colleagues dialing into the observatory's computer network. Concurrent with setting up the observatory, we will negotiate the installation of a dedicated relatively high-speed data link between the observatory and the nearest Department of Interior facility.

Power requirements:

Data acquisition and analysis equipment do not use high power, but do require reliable power for the equivalent of 10-15 standard desktop computers (total about 3-5 kW). If reliable power is not available, it may be necessary to obtain a backup generator and quality uninterruptible power supplies.

Doppler radar

Doppler radar requires a 6' x 6' rooftop space, capable of supporting about 300 lbs, with line-of-sight to the volcano for the possible installation of a Doppler radar. Ideally, the radar would be located within a few hundred feet of the operations room. The radar requires about 1 kW.

Parking

Workers will travel frequently between the volcano, a local helipad, and motel rooms, etc. Convenient, secure parking for 8-10 vehicles would be a blessing.

APPENDIX E: JOINT INFORMATION CENTER PURPOSE AND STRUCTURE

Coordination of information flow

The purpose of a JIC is to coordinate the flow of information about volcanic activity and related response issues among agencies, and to provide a single information source for the media, business and general public. The JIC is an element of the Emergency Operations Center (EOC) where the emergency response is being coordinated. Communication between agencies and to the media and public must be rapid, accurate, and effective, and a JIC provides a forum for the necessary information exchange. Public information between and from all responding agencies, emergency operations centers, political jurisdictions, and the media are handled through this one center, thereby allowing the coordination of information from all sources, and reducing or eliminating conflicting information and rumor. Temporary media offices at the Washington Emergency Management Division (EMD) encourage an efficient flow of information from the JIC.

A JIC may be necessary in one or more of the following circumstances:

- Multiple local, state and federal agencies are involved in the information dissemination about the incident.
- The volume of media inquiries overwhelms the capabilities of the public information officers within the emergency operation center.
- A large scale public phone team effort must be mounted over an extended period of time.

When conditions warrant, or when a Volcano Advisory is declared, a JIC will be activated by the Facilitating Committee (FAC) and/or the Multi-Agency Coordinating (MAC) Group. A JIC facility must have office space for the public information officers, facilities for communication by FAX, phone, and email, briefing rooms, easy access for the media, available food service, and security.

Recommended structure of Joint Information Center during a volcanic incident

A. **Potential Participants:**
   Washington State Emergency Management Division
   U.S. Geological Survey
   National Park Service
   U.S. Forest Service
   Washington Department of Natural Resources
   Snohomish County Department of Emergency Management
   Whatcom County Division of Emergency Management
   Skagit County Department of Emergency Management
   Others as required

B. **Operating Assumptions:**
   1. All information will be coordinated among the response staff in order to ensure timely and accurate information flow to the public, to quell rumors, and to prevent interruption of the response effort.
   2. JIC will operate under incident command system.
   3. The JIC will adjust its size and scope to match the size and complexity of the event.
   4. State and local agencies may be requested to provide staffing for the JIC as necessary.

APPENDIX F: REFERENCES AND WEB SITES

References:

On Mount Baker and Glacier Peak

Beget, J.E., 1982, Recent activity at Glacier Peak, *Science*, v. 215, pp. 1389-1390.

Beget, J.E., 1983, Postglacial volcanic deposits at Glacier Peak, Washington, and potential hazards from future eruptions, USGS Open-File report 82-830.

Gardner, Cynthia A., Scott, K.M., Miller, C.D., Myers, B., Hildreth, W., and Pringle, P.T., 1995, Potential Volcanic Hazards from Future Activity of Mount Baker, Washington, Open-file Report 95-498, 16pp.

Hyde, Jack H. and Crandell, Dwight R., 1978, Postglacial volcanic deposits at Mount Baker, Washington, and potential hazards from future eruptions: U.S. Geological Survey Professional Paper 1022-C, 17pp.

Mastin, L.G., and Waitt, R.B., 2000, Glacier Peak—History and Hazards of a Cascade Volcano, U.S. Geological Survey Fact Sheet 058-00.

Scott, K.M., Hildreth, W., and Gardner, C.A., 2000, Mount Baker—Living with an Active Volcano, U.S. Geological Survey Fact Sheet 059-00.

Waitt, R.B., Mastin, L.G., and Beget, J.E., 1995, Volcanic-Hazard Zonation for Glacier Peak Volcano, Washington, U.S. Geological Survey Open-File Report 95-499, 9pp.

On volcanic crises and volcanic hazards

Blong, R.J., 1984, Volcanic Hazards: New York, Academic Press, 424 p.

Foxworthy, B.L., and Hill, M., 1982, Volcanic eruptions of 1980 at Mount St. Helens: The first 100 days. USGS Prof. Paper 1249: Washington, D.C., U.S. Government Printing Office.

Harnley, C. D., and Tyckoson, D. A., 1984, Mount St. Helens: An Annotated Bibliography, Scarecrow Press, Inc., Metuchen NJ and London, 248 pp.

International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI), 1995, Understanding Volcanic Hazards [video]. Distributed by Northwest Interpretive Association, (360) 274-2127.

International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI), 1995, Reducing Volcanic Risk [video]. Distributed by Northwest Interpretive Association, (360) 274-2127.

Mader, G.G., Blair, M.L., and Olson, R.A., 1987, Living with a volcanic threat: Response to volcanic hazards, Long Valley, California, William Spangle and Associates, Inc., 105 pp.

Newhall, C. G., and Punongbayan, eds., 1996, Fire and Mud: Eruptions and Lahars of Mount Pinatubo, Philippines, 1126 pp.

Tilling, R.I., ed., 1989, Volcanic Hazards. American Geophysical Union Short Course in Geology: Volume 1, American Geophysical Union, Washington D.C., 123pp.

Web sites:

American Red Cross	http://www.redcross.org
British Columbia Provincial Emergency Program	http://www.pep.bc.ca
FEMA	http://www.fema.gov
Geological Survey of Canada	http://www.nrcan.gc.ca/gsc/pacific/vancouver
Mount Baker-Snoqualmie National Forest	http://www.fs.fed.us/r6/mbs
Pacific Northwest Seismic Network	http://www.geophys.washington.edu/SEIS/PNSN/
Skagit County DEM	http://www.skagitcounty.net/offices/emergency_management/main.htm
Snohomish County	http://www.co.snohomish.wa.us
Snohomish County DEM	http://www.snodem.org
USGS Cascades Volcano Observatory	http://vulcan.wr.usgs.gov
Washington State Department of Natural Resources	http://www.wa.gov/dnr/
Washington State Emergency Management	http://www.wa.gov/wsem
Whatcom County	http://www.co.whatcom.wa.us
Whatcom County DEM	http://www.co.whatcom.wa.us/dem/home.htm